Renewable and Sustainable Energy Reviews 15 (2011) 2838–2849

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Review of best practices of solar electricity resources applications in selected Middle East and North Africa (MENA) countries

Antonis Tsikalakis[a,*], T. Tomtsi[a], N.D. Hatziargyriou[a], A. Poullikkas[b], Ch. Malamatenios[c], E. Giakoumelos[c], O. Cherkaoui Jaouad[d], A. Chenak[e], A. Fayek[f], T. Matar[g], A. Yasin[h]

[a] School of Electrical and Computers Engineering, National Technical University of Athens, 9 Heroon Polytechniou Str, Athens, Greece
[b] Electricity Authority of Cyprus, Cyprus
[c] Centre for Renewable Energy Sources and Saving (CRES), Greece
[d] CDER - Centre de Développement des Energies Renouvelables, Morocco
[e] CDER - Centre de Développement des Energies Renouvelables, Algeria
[f] New & Renewable Energy Authority (NREA), Egypt
[g] Lebanese Association for Energy Saving & for the Environment (ALMEE), Lebanon
[h] Palestinian Energy & Environment Research Center (PEC), Palestine

ARTICLE INFO

Article history:
Received 18 October 2010
Accepted 22 December 2010

Keywords:
Distributed energy resources
Photovoltaic (PV)
Renewable energy sources (RES)
Concentrating solar power
Power systems
MENA countries

ABSTRACT

Middle East and North Africa (MENA) countries present abundant solar potential, which to some extent has been exploited for electricity production. However, the largest part of this potential remains still unexploited. The scope of this paper is to present the best practices in exploiting solar energy in selected MENA countries. First the general structure of energy market related to Renewable Energy Sources (RES) for each analyzed country is presented. Then the exploitation of solar energy via PVs with special focus to the achievements in rural electrification, which could be used as a paradigm for other countries with similar problems, is displayed. MENA countries are promising for the wide application of concentrating solar plants (CSP), as recent research has shown, and some interesting applications in this area, also presented in this paper, have started being implemented.

Contents

* Corresponding author. Tel.: +30 210 772 3696; fax: +30 210 772 3968.
E-mail addresses: atsikal@power.ece.ntua.gr (A. Tsikalakis), ttomtsi@gmail.com (T. Tomtsi), nh@power.ece.ntua.gr (N.D. Hatziargyriou), apoullikas@eac.com.cy (A. Poullikkas), malam@cres.gr (Ch. Malamatenios), egiakou@cres.gr (E. Giakoumelos), o.cherkaoui@cder.org.ma (O.C. Jaouad), chenaka@cder.dz (A. Chenak), aymanfayek@yahoo.com (A. Fayek), tmatar@dm.net.lb (T. Matar), Ayasin@perc.ps (A. Yasin).

1364-0321/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2011.03.005

1. Introduction

Mediterranean countries present very high solar potential, as shown in the solar map in Fig. 1. Clearly direct solar irradiance in south Mediterranean countries, i.e. Middle East and North Africa (MENA) countries, is much higher than the one in north Mediterranean countries (i.e. South Europe). Moreover, in MENA countries there are fewer restrictions in space available due to desert areas, while some of the rural areas have not been electrified yet or are under electrification with decentralized ways of connection. The large space combined with the abundant solar resources has made this region one of the promising areas for the installation of Solar Energy plants for providing electricity, as the DESERTEC initiative describes [1].

The DISTRES project (full title: "Promotion and consolidation of all RTD activities for renewable distributed generation technologies in the Mediterranean region") [2], financed by the 6th Framework Program for Research and Development of the EU as an International Co-ordination action (INCO project) for the period January 2007 to December 2009, had as main area of interest the electricity produced from renewable energy sources (RES) – solar thermal and photovoltaic – Distributed Generation (DG) systems. This focus was justified by the abundant solar potential in the Mediterranean region and the progress that some of the Mediterranean countries have made.

The development of a comprehensive course structured into four complementary teaching modules that can be specifically taught to local Mediterranean audiences is one of the highlights of this project. Thus, further dissemination among both the Mediterranean countries and the EU beyond the duration of the project is possible, additional to the workshops and the international conference organized throughout the project. An overview of this specific material for MENA countries is provided in the following sections, with more focus to countries that have participated in the DISTRES project (Morocco, Algeria, Egypt, Palestine and Lebanon).

More precisely, a summary of the main stakeholders and the targets set by the authorities of each country are analyzed. More focus is given on the review of promising applications regarding utilization of solar power to produce electricity. These countries have, either to a greater extend, like Morocco, or to a smaller one, like Lebanon, utilized PVs for electrification of rural population. The way these countries have acted for improving the electrification rate is explicitly described below and some of the solutions they have found can act as a good paradigm for other areas of the world facing similar problems. Moreover, their ambitious plans for investing in and installing solar thermal plants are presented in more detail. In Section 3 a comparative presentation of the major characteristics for the countries presented is provided. Finally, conclusions are provided in Section 4.

2. Presentation of the countries analyzed

2.1. Morocco

Morocco has approximately 30 millions population rapidly growing and becoming increasingly urban (currently representing more than 55% of the total). The rate of economic growth varies from year to year and has been on average 3.8% for the last three decades. Energy needs are growing even faster due to changes in life style.

The country also depends greatly on imports of crude oil and oil products, as well as of coal and electricity. The result is that both the energy bills and the rate of dependence on energy (97%) are very high. An important progress in the energy sector has been made in the last few years, mainly related to the diversification in the sources of supply and the initiatives taken towards market liberalization. Small Hydro contributes around 3–4% of the electricity produced in Morocco.

The major stakeholders and the country's targets on RES are described in the following subsection.

2.1.1. Main stakeholders and review of policies

The Ministry of Energy and Mines is responsible for the energy planning of the country and for granting any authorizations related to the energy sector [3]. The national utility company, National Office of Electricity (ONE), ensures the planning and realization of the national electrification programs. CDER (Centre de Dèveloppement des Energies Renouvelables) [4] is responsible for RE planning, implementation and follow up of RE programs and projects in Morocco. RES companies like Temasol [5] are used to act as subcontractors of ONE for the rural electrification projects in Morocco. This practice has helped Morocco to make significant progress in solar energy exploitation; 10% of the rural households have been electrified with the use of autonomous PV systems as will be thoroughly described. During the past 10 years, using the PERG initiative [6], the rural electrification rate has risen from 18% in 1995 to 98% in 2007. If an energy related project has to be connected to the grid, an authorization is required from ONE and the Ministry of Energy and Mines. Finally, the Association for Solar and Renewable Energy (Association Marocaine de l' Industrie Solaire – AMISOL) is an organization that supports RES (especially solar energy).

Morocco has as target that by 2012, 20% of the electricity and 10% of the total energy mix will be produced from RE. By the same year, 300 MW of wind power are expected to be installed, compared to the current 114 MW, while CSP plants are intended to play a significant role in achieving these targets as described below.

2.1.2. Best practices

2.1.2.1. Rural electrification. Morocco has long history in rural electrification dating back in 1963 when ONE, with its own resources, began extending the transmission and distribution networks (those in the rural areas included). This first period lasted till 1981. In the meantime, more precisely in 1978, they started planning the PNER (National Program for Rural Electrification) project; by then the total number of rural households supplied with electricity was about 130,000. PNER consisted of two phases. During the implementation of the first one (1982–1986), 287 rural villages representing 68,000 households were electrified. This phase of PNER was financed by 50% by the State and 50% by local authorities. Moreover, a loan by the International Bank for Reconstruction and Development (IBRD) of 30 million dollars was granted. The second phase of PNER started in 1991 and electrified 843 villages representing 155,000 households. PNER II was 100% financed by

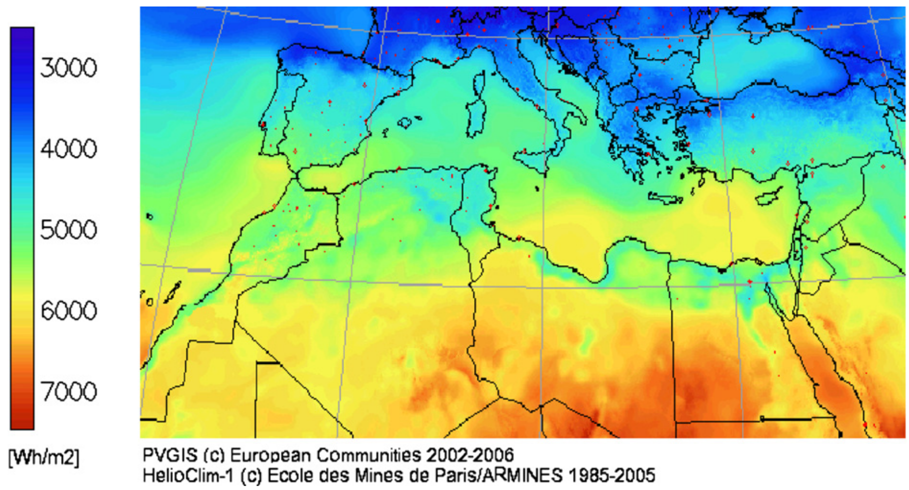


Fig. 1. The average daily solar radiation resource in Mediterranean countries.

local authorities and benefited of a loan from the European Investment Bank (EIB) of 30 million € and a loan of 114 million $ from IBRD.

The Pilot programme of rural pre-electrification (PPER – Programme Pilote de Pré-Electrification Rurale) was in fact the first attempt to substitute a program logic for a vision of projects in the field of rural electrification off the grid. Built on a Moroccan-French financing scheme, the PPER has been implemented jointly by the Ministry of Energy and Mines (Energy Division), the Ministry of Interior (General Division of the local communities), and CDER. PPER planned the equipment for 240 villages distributed over three provinces: Azilal, Errachidia and Safi. In 1995, 30 villages (1500 houses) in these three provinces were equipped with one of the following or combination of decentralised solutions:

- individual solar system;
- collective solar system (battery recharging); and/or
- mini grid

It should be noted that solar solutions have accounted for some 70% of this program.

Despite the huge efforts, the electrification rate through the interconnected grid did not increase considerably the electrification rate of Morocco. In order to phase this issue, the introduction of the decentralised option via the Global Rural Electrification Program (PERG) has followed, starting in 1995. This was a program of the National Power Office (ONE) of Morocco with governmental support. The financing of the project came from various sources. The Equipment Grant of 22.1 million € from ONE includes a 5 million € donation from the KfW German Bank, a 5 million € soft loan from the French Development Agency (AFD), about 1.25 million € from FFEM (the French Fund for the World Environment), 3.5 million € from Company's shareholders and another 3.2 million € via connection fees from customers.

Since 1998, the introduction of PV kits was considered as a means of rural electrification. In 1999 it was decided that the private sector should participate as well. Both these actions accelerated the electrification rate in Morocco. Revamped specifications, in particular with regard to the acceptance procedures and methods of payment, work monitoring decentralization, henceforth provided by Regional Technical Services, simplification of contract management procedures, and quality control of completed works were some of the parameters that lead to this acceleration.

In order to optimally connect areas the use of Geographical Information Systems (GIS) and Distribution Network Planning Software was decisive. The potential ways of electrifying settlements in Moroccan rural areas are shown in Fig. 2.

In this way, rural electrification can be increased at reasonable cost stating that, if grid electrification cost exceeds 2400€, then a Solar Home System (SHS) should be the option.

In order to proceed with the decentralized option, one operator acts as a delegated manager for ONE. The operator buys and installs SHS – paid by monthly fee and grants from ONE, while the equipment is property of ONE. The operator operates, maintains and renews the equipment for 10 year and the cost is covered by the customer's "Fee for Service".

An example of such an operator is Temasol [5]. This company's head office is in Rabat with local backing up agencies close to customers. The communication with people, new application and payments mainly take place on the local weekly markets (souks). Thus, the locals do not have to change their habits in order to pay their fee for service. The operator, once a contract is signed, has to make the installation and supply the equipment within 15 days. Moreover, once a year maintenance of the equipment, such as batteries, etc. is performed and in case of unexpected problems in the equipment, the operator should be able to respond within 48 h [8].

The ONE participation amounts to 5100 DH (i.e. 452.8€) on average, excluding tax, and the consortium pre-finances the complement payable by the user. The participation of the beneficiary household for a 50 W kit includes an advance of 700 DH (i.e. 62.2€) (excl. tax) and a monthly fee of 65 DH (below 6€) (excl. tax) for 10 years. Similar structures apply for 75 W_p or 200 W_p, as Table 1 shows. The simplest electrification system consists of some lamps (usually compact fluorescent lamps) and the availability of one

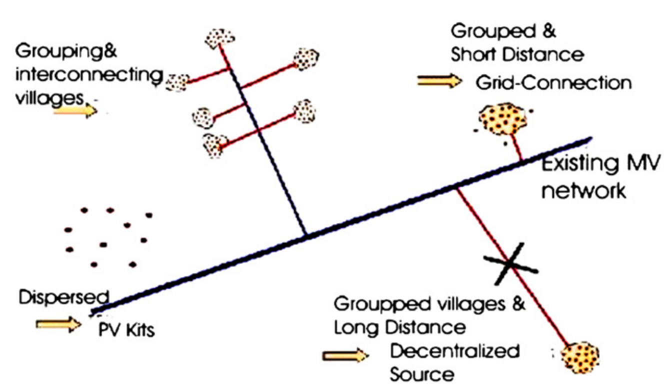


Fig. 2. Potential ways of electrifying settlements in Morocco.

Table 1
Typical charges for various capacities of PV kits.

Installed capacity	ONE participation	Advanced payment for beneficiary	Monthly fee
75 W_p	5500 DH (486€)	900 DH (80€)	65 DH (6€)
200 W_p	11,000 DH (972€)	4000 DH (354€)	150 DH (13.5€)

12 V socket operating in DC. Thus, the system is very simple since no inverter is required. New tenders give the ability of increasing capacity and adding a fridge.

Within PERG, additionally to the above actions, other RES sources were used as well. More precisely, in 2000 one wind turbine of 15 kW was installed to electrify 71 homes in the village of Moulay Bouzerktoune (Province of Essaouira) and 2 wind turbines of 25 kW each in the village of Sidi Kaouki helped in electrifying 52 additional homes. In 2002, CDER, launched a study in the Provinces of Essaouira and Safi. According to this study 22 villages were eligible to be electrified by wind systems.

Hydropower was also exploited under PERG:

- the micro-hydropower plant of Askaw of 200 kW allows supplying 30 villages in the commune of Iguidi near Agadir, i.e. 593 homes;
- the micro-hydropower plant of Oum-Rbaî (Khenifra province, commissioned in December 2004) of 200 kW can supply 18 villages, i.e. 556 homes and administrative buildings that come under the commune of the Oum Errbia springs, through an isolated grid;
- a third micro-hydropower plant (Maaser plant) that will supply 6 villages (about 344 houses) through isolated grid, is considered.
- Within the Micro-Hydropower Plants (MHP) programme, undertaken by CDER, pilot experiences of MHP projects (up to 100 kW) have been realised in the Haut Atlas (Haouz Region) and in several mountainous regions (Azilal, Asni, Ouneine, Tighdouine...).

In parallel, some other actions were implemented, such as "The Village Power" (Moroccan-Spanish co-operation), which has electrified 12 villages in the Northern Provinces (2500 houses in Chefchaouen, Taounate...), and the "Regional Energy Supply Plan" (SAER – Schéma d'Approvisionnement Energétique Régional), which resulted in equipping over 400 homes and creating associations of projects beneficiaries.

All these actions have helped so that, by September 2002, 16,000 Households (150,000 inhabitants) had been electrified in this way. During the period 2003–2005, 4 tenders for 93,000 households were issued [6]. By the end of 2006, 27,373 villages were supplied with electricity (1,598,441 households). Only during 2006, 78,286 households were electrified and by the end of 2007 PERG has signified the electrification of more than 35,000 villages providing access to electricity for up to 12 million people in the rural areas and a total budget of 20 billion DH.

By the end of 2008, 38,500 villages were supplied with electricity (2,014,000 households). The great progress in rural electrification is depicted in Fig. 3. It should be mentioned that 10% of these households have been electrified using PV kits only.

Additionally to these actions, a demonstration project employing FFEM, TEMASOL and ONEP [7] National Office for Potable water) for remote villages aims to promote solar pumping. 10–15 villages will be equipped and operated aiming for providing water to about 6000 people. The management will be performed by local population associations. Currently, 4 solar pumps have been already installed, with 900 persons served. Part of the cost will be covered by ONEP, which brings 0.36 mill €, and FFEM with 0.4 mill €. Moreover, 29 installations of PV pumping systems are foreseen via a number of MEDA/SMAPII projects [9].

2.1.2.2. Social impacts of rural electrification in Morocco. The extension of rural electrification in Morocco has helped so that many more people now receive electricity, thus improving their life conditions. Moreover, it is estimated that the PERG programme has created more than 100 direct and 80 indirect jobs. Most of the owners of small shops have stated that they have extended their operating hours and have noticeable increase of profits. Young students can prolong their reading time as well. The penetration of refrigerators has been increased and new social activities (cafes, restaurants) have been developed. Simultaneously, farming has been improved mainly via solar pumping. 85% of the customers have TV sets and 53% have mobile phones [10,11]. 98% of the customers have stated that they are satisfied by the equipment and services. Based on this positive impact, ONE has expressed the willingness to prolong PERG via PVER (Plan de Valorisation de l' Electrification Rurale) [12].

2.1.2.3. Concentrating solar power plants. Morocco has recently announced an ambitious plan for the development of Integrated Solar Energy projects combined with Combined Cycle Units [13]. 5 potential sites have been identified for the development, covering 10,000 hectares of land, as described in Table 2. The installed capacity will reach 2000 MW, and the contribution in electricity production (around 4500 GWh/year) is expected to be 18% of current demand. The first plant will be brought in service by 2015 and the last by 2019. The estimated investment is expected to reach 9 Billion $.

In order to promote the targets of the project, a dedicated agency will be established, the Moroccan Agency for Solar Energy, which will conduct overall project design, choice of operators, implementation, management, co-ordination and supervision of other activities related to this program. The choice of developers for the plants will be based on competition and with open technologies options, while a request for proposals for qualified project developers is expected within 2010.

2.1.2.4. The first integrated solar combined cycle power plant in operation. On May 12th, the king of Morocco inaugurated the installation in Ain Beni Mathar in the centre of Morocco. This site is very close to the Maghreb-Europe Gas Pipeline, close to the High Voltage electricity grid of 225 kV, while sufficient water for cooling and cleaning the solar collectors exists. The plant has a system for recovering, treating and stocking liquid waste in a 6 hectare-air tight basin. This reduces the water needs by 80% from a current 5.4 million m^3 to 850,000 m^3 per year.

The installed capacity of the power plant is 472 MW, consisting of 20 MW solar energy field with cylindrical parabolic solar collectors [14]. The conventional part of the power plant consists of two gas turbines of 150 MW each and one steam turbine of 172 MW. Up to this part the power plant operates as a conventional combined cycle unit using natural gas. The advance beyond this type of unit is the fact that hot water is provided from the solar collectors to the gas turbines in order to reduce the fuel required to achieve the same mechanical work. Additionally, the condenser helps in reducing water requirements since water is recycled within the power plant.

The total area covered is 160 ha, of which 88 ha have been allocated to the solar island. The total surface of solar collectors is

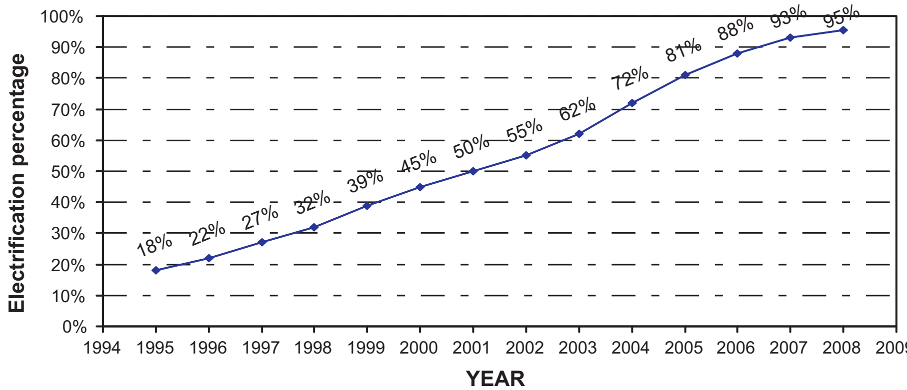


Fig. 3. The rural electrification percentage for Morocco due to PERG.

Table 2
Considered plans for CSP in Morocco.

Site name	Direct normal insolation (kWh/m^2/year)	Capacity (MW)	Surface (ha)	Estimated production (GWh/y)
Sebhate Tah	2140	500	2500	1040
Foum Al Quad	2628	500	2500	1150
Ain Beni Mathar	2290	400	2000	835
Ourzazate	2635	500	2500	1150
Boujdour	2642	100	500	230

183,200 m^2. The solar field is has an inlet heat transfer fluid temperature of 292 °C and an outlet temperature of 392 °C. This project could generate 3538 GWh annually, that is 13% of the 2010 national demand and the solar collectors are expected to save 12,000 tons of fuel and reduce by 33,500 tons of CO_2 yearly emissions.

The whole investment is worth 4.6 billion Moroccoan Dirhams (over 526 million$). The major funding comes via the African Development Bank (AfDB), financing approximately two-thirds of the cost of the plant, or about 187.85 million €. The rest of financing comes from the Global Environment Facility (GEF) [15] (a grant of 43.2 million $), while the Instituto Oficial de Crédito (Official Credit Institute) also contributed to this installation. The rest of the capital comes from ONE, the owner of this plant. The engineering design was made and the solar collectors have been built by Abengoa (Spain). ALSTOM has provided the gen-sets, while a local civil engineering company has contributed to the civil works required, thus increasing local employment.

2.2. Algeria

With its 2,381,741 km^2 of total land area, Algeria is by far the largest country of the Mediterranean. According to a study of the German Aerospace Agency on "Solar Thermal Power Plants for the Mediterranean", Algeria has with 1,787,000 km^2 the largest long term land potential for concentrating solar power (CSP) plants. Additionally, Algeria, unlike neighbouring Morocco, is one of the countries with the highest Natural Gas production in Africa.

2.2.1. Main stakeholders and review of policies

The major Supervising Organizations in the Algerian energy sector are the Ministry of Energy and Mining [16] and the Ministry of Environment. The former is in charge of all aspects of energy in the country, from managing oil and gas production and trade policies to domestic market distribution policy. The latter is connected to all the aspects of sustainable development and environmental protection policies, e.g. legislation of industrial emissions control and standards, etc.

The Electricity and Gas Regulation Commission (CREG) [17] is responsible for demand forecasting, capacity licensing, awarding concessions for generation and distribution, as well as for setting the environmental and quality regulations and the tariffs.

APRUE (Agency for the Promotion & the Rationalisation of Energy Use) [18] is the national institution responsible for the promotion and implementation of the energy conservation policy (energy efficiency, renewable energy and environmental protection related to energy consumption). Its principal role is the coordination and monitoring of the energy conservation policy (national programme for energy conservation, national funds, etc.). Another public institution, established in 1988 being part of the Ministry of High Education and Scientific Research, is CDER (Renewable Energy Development Centre) [19]. CDER is devoted to initiate and elaborate scientific and technological programs of research and development on power systems exploiting solar, wind, geothermal and biomass energies.

Key stakeholders for the Algerian energy sector are SONELGAZ (National Society for Electricity and Gas) and its affiliated company CREDEG (Electricity and Gas Research and Development Centre) [20]. Since 1996, Algeria's energy sector monopoly was attributed to SONELGAZ, being responsible for power generation, all aspects of the national grid (including expansion, maintenance and operation), and low-voltage distribution of electricity. In 2002, a special law on electricity and gas distribution was passed for the abolition of SONELGAZ's legal monopoly over power production. Key aspect of this law is the necessity for unbundling of SONELGAZ activities as well as the establishment of an independent regulator. Moreover, SONATRACH is an Algerian government-owned company formed to exploit the hydrocarbon resources of the country [21].

In order for renewable energy systems to be promoted in the country, the Electricity Law of 5th of February 2002 was set. This law mainly states that renewable electricity can be either financed through feed-in tariffs or directly by the state.

In July 2002, SONATRACH, SONELGAZ and an Algerian private company (SIM) formed a new renewable energy joint venture company called New Energy Algeria (NEAL: SONATRACH 45%, SONELGAZ 45% and SIM 10%) [22]. Among NEAL's strategic objectives is the identification and implementation of projects related to new and renewable energy sources as well as the development and conduct of relative industrial and commercial activity.

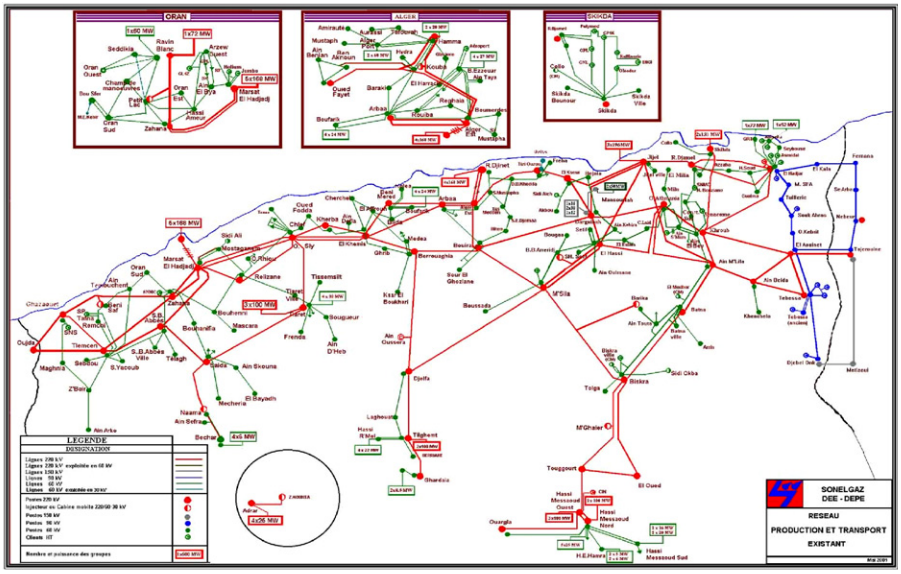


Fig. 4. The transmission network map for Algeria.

Moreover, the Feed-in tariff Decree of 25th of March 2004 has defined "premium" levels for power generated from solar energy and especially for CSP Plants, as described below:

- 300% of market price for the power produced totally by solar,
- 200% of market price if more that 25% of the power is produced by solar–gas hybrid with solar, and
- 100–180% of market price in the case that the percentage of the produced power by solar–gas hybrid with solar is less than 25%.

Algerian authorities have set as target the solar energy and/or co-generation applications to reach 5% of the energy mix by 2015 and increase the share of RES in electricity production to 10% by 2027. Potential ways of achieving these targets using various RES have been described in a recent paper [23]. In order to help in these efforts a review of legislation is currently underway. Significant boost is also expected after the construction of the PV manufacturing plant in Rouiba area with expected capacity of 50 MW/year. This plant is within the strategic plan of the SONELGAZ and its affiliated subsidary, Sonelgaz socéiété of Engineering.

2.2.2. Best practices

2.2.2.1. Rural electrification. The vast majority of the Algerian territory is a desert land with very few inhabitants and harsh conditions, but simultaneously abundant solar energy resources. It is estimated that an area of 1 million km^2 has not been electrified yet, as the map of the transmission network shows in Fig. 4, and is technically very difficult, if not impossible, to be electrified by traditional means of extending transmission networks. It should be noted that there are areas that form autonomous power systems within Algeria. The installed capacity of diesel units which usually serve these areas is about 175 MW. It is estimated that 183 units with individual rating varying between 0.35 MW and 8 MW have been installed in the South and feed separate networks.

Thus, some first actions for electrifying remote villages in this vast Southern area have taken place. By 1990 the installed capacity was in the order of 250 kWp [24]. However, some significant more efforts focusing on rural electrification have been made since then. One of these efforts was the electrification of 20 villages in various Wilayas (provinces) in the Sahara desert. 453 dwellings were electrified with installed capacity of 1000 homes achieved, mainly based on the implementation of 108 photovoltaic systems with total capacity of 500 kW. The electrified villages were scattered in a region of about 1 million km^2, i.e. about twice the land area of France as clearly shown in Fig. 5. More details on the number of homes electrified and the capacity of PV systems considered are provided in Table 3. Systems of 1.5, 3 and 6 kW were used for this purpose.

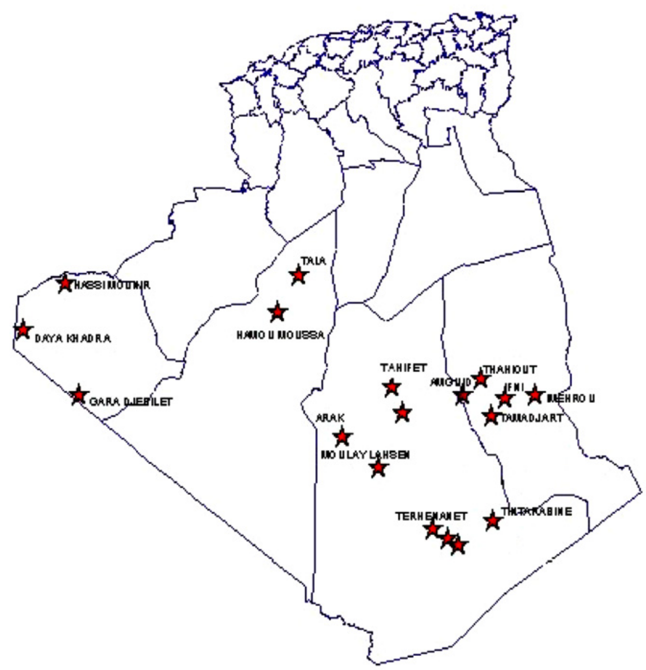


Fig. 5. The electrified solar villages.

Table 3
Electrified villages in Algeria via PVs.

Wilaya	Number of connected homes	Installed capacity (kWp)
Tindouf	156	78
Adrar	45	22.5
Illizi	150	75
Tamanrasset	555	277.5

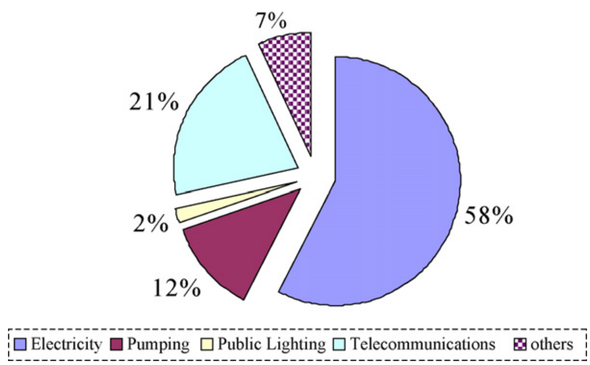


Fig. 6. Allocation of applications of PVs in Algeria.

Other achievements of this action are the construction and operation of a central Hybrid PV-Diesel station of 13 kW_p at Illizi (300 dwellings or about 2000 habitants), the electrification of more than 100 telecommunications sites (power of 650 kW_p) and around 20 security posts (constabulary, communal guards...), and beaconing of 2300 km of paths. An allocation of the installed capacity of PVs in Algeria to various applications is provided in Fig. 6. Pumping constitute a significant portion of these installations and experience from the operation under Saharan conditions have been described in [25].

2.2.2.2. Concentrating solar power plants. The "Hassi R'mel", an Integrated Solar Combined Cycle (ISCC) plant of 150 MW, is currently under construction in northern Algeria, in an area close to gas pipelines and high voltage grid. This project is being promoted by solar power plant one (SPP1), an Abener and NEAL joint venture formed for this purpose, which will operate and exploit the plant for a period of 25 years. The plant construction started on the 7th of November 2007 and is expected to be finished by November 2010. SONATRACH will buy all of the power produced, which is expected to reach 1250 GWh/year.

The plant consists of a conventional combined cycle and a solar field with a nominal thermal power of 95 MW_{th}. The 25 MW solar field of parabolic trough technology of the plant will provide complementary thermal energy to the combined cycle. The solar field is composed of 216 solar collectors in 54 loops with an inlet heat transfer fluid temperature of 290 °C and an outlet temperature of 390 °C.

The "Hassi R'mel" plant will use the heat generated in the same steam turbine that makes use of the waste heat from the gas turbine for electricity generation. This configuration is double effective, since not only minimizes the investment cost but also reduces the CO_2 emissions associated with the conventional plant.

The 20% of the project cost (63 million €) is financed by shareholders, and the rest 80% (252 million €) is financed by local banks (BEA – 54.72%, CPA – 20.03% & BNA – 25.25%) on a non-recourse project financing basis. Project assets and cash flow are the only security to lenders, while the project cash flow is used to service the debt and distribute dividends. Finally, a 15-years of repayment "soft loan" of 3.75% interest rate has been received to reduce the impact of financing charges on tariffs [26].

2.3. Egypt

Egypt is located within the Sun Belt countries with annual global solar insolation ranging from 1750 to 2680 kWh/m^2/year from North to South and annual direct normal solar irradiance ranging from 1970 to 3200 kWh/m^2/year from North to South, with relatively steady daily profile and small variations making it very favourable for utilization. Such a solar resource utilization is supported by other conditions, such as the daily sunshine duration ranging from 9 to 11 h with few cloudy days over the year. Desert areas with almost no inhabitants in Egypt exceed 90% of the country's area of 1 million km^2. A recent study estimated the solar electricity economic potential, using the annual direct normal irradiance with a conversion factor of 0.045, which takes into account an average annual efficiency of 15% (state of the art for parabolic troughs) and a land use factor of 30% for CSP technology. This economic potential considers only suitable sites with direct normal irradiance higher than 2000 kWh/m^2/day. The study concluded that Egypt has an economic potential for solar thermal electricity generation of about 73.655 TWh/year The study foresees CSP as a key solution for the rising demands of electricity and water in the future, not only on the national level but also for clean electricity exports from there to Southern Europe.

2.3.1. Main stakeholders and review of policies

The main stakeholders in Egypt are the Ministry of Electricity and Energy [27] and the New & Renewable Energy Authority" (NREA) [28]. Among the major activities of the former is to settle the General Plan of the Energy Generation, Transmission and Distribution and to supervise the study and execution of essential electrical projects. In addition, they suggest the electric energy prices for all the various voltage levels and customers.

NREA was established to act as the national focal point for expanding efforts to develop and introduce renewable energy technologies in Egypt on a commercial scale, together with the implementation of related energy conservation programs. In order to achieve these targets, various testing facilities have been installed. NREA is also entrusted to plan and implement projects focusing on solar, wind and biomass, in coordination with other relative national and international institutions. They are responsible for the Egyptian standard specifications for renewable energy equipment and systems, while they provide consultancy services in the field of RES to other organizations and authorities.

It is worthy to mention that Egypt has adopted a long term strategy to satisfy by 2020 20% of the generated electricity by RES, including a 12% contribution from wind energy (i.e. about 7200 MW) while the rest will come from hydro, solar thermal and other RES. In order to achieve these targets, the Egyptian authorities will try to enhance the local industrial capabilities in the field of renewables and will try to benefit from Kyoto Protocol Mechanisms.

2.3.2. Best practices

In addition to the favourable solar conditions, Egypt enjoys very favourable wind conditions especially along the Red Sea coast line, with 10 m/s average wind speed. There are about seven companies working in the field of PV solar systems in Egypt, some of them working in PV modules assembly with production capacity of about 500 kW_p per year. According to NREA's estimations, approximately 500,000 m^2 of Solar Water Heaters (SWH) have been installed in Egypt in residential, commercial and tourism buildings. Domestic SWH are not widely spread as anticipated due to several reasons, among them being the subsidized N.G. pricing and the low electricity tariffs.

2.3.2.1. Rural electrification. Even though Egypt has significant percentage of desert very few remote electrification applications exist compared to the other two neighbouring countries.

NREA signed a protocol for cooperation with the Italian Ministry of Environment, Sea and Land to electrify 2 remote settlements in Matrouh Governorate with PV systems of about 43 kW installed capacity. The project is under implementation and it is planned to be operated by mid 2010. This project will provide electricity to 100 households, 80 street poles, 3 mosques, 2 clinics and 1 school.

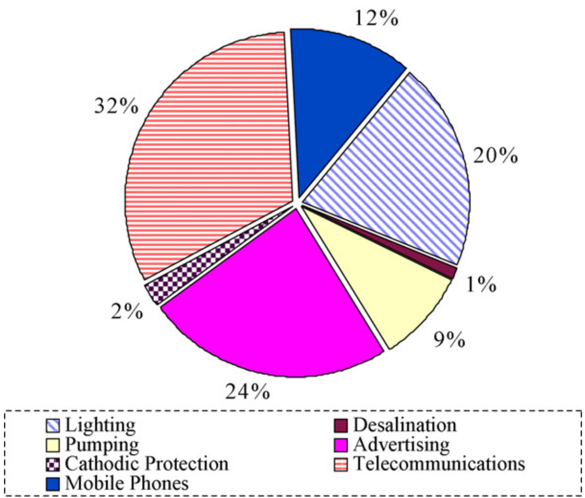


Fig. 7. Allocation of PVs applications in Egypt.

Moreover, a PV system has been used to light one of NREA's remote sites at Matrouh Governorate, with a total capacity of 424 W peak for 9 × 11 W (DC) efficient lamps, and a TV set of 60 W (AC).

There are also some remote applications such as telecommunication stations, ice making factories, lighting, desalination, etc. An allocation of PV installations is provided in Fig. 7.

Further Rural Electrification of 121 rural villages via PV or PV/Diesel Systems is under investigation and the expected required capacity is about 1.2 MW_p. Thus, access to lighting, potable water and communications can be much easier achieved in remote areas. Moreover, PV irrigation systems are foreseen for remote areas away from electricity infrastructures.

2.3.2.2. Concentrating solar power plants. Before proceeding with the large scale application of CSP projects, a pilot project, the "El Nasr" one, was implemented and commissioned in a pharmaceutical company, in cooperation with the African Development Fund. This project aimed at energy savings and heat recovery from waste disposal. One part of the system was the set of solar parabolic collectors with total area of 1900 m^2 and saturated steam generation of 0.8 ton/h (175 °C, 8 bar). About 70% of the system was locally manufactured including the parabolic collectors, for the first time in Egypt, the aluminum structures and the metallic joints. The components of the solar system had been assembled and erected at the site, in addition to the storage tanks, pipe networks and civil & electrical works [29]. This plant has been operational since 2003.

In 1996 a first feasibility study on potential sites for exploiting CSP was performed [30]. Among the 3–4 suggested sites, the Kurayamat site was allocated as the most promising one. Kurayamat is an uninhabited flat desert land with expanded natural gas pipelines, 90 km south from Cairo, the major consumption centre, located near to water sources (the River Nile) and very close to the interconnected power grid, the direct solar radiation intensity of which reaches 2400 kWh/m^2/year. All of these characteristics have made Kurayamat the most promising site for CSP construction. The first Integrated Solar Combined Cycle plant in Egypt is currently under construction there. The plant is expected to be brought in operation in October 2010 [31]. The first parabolic trough was constructed in January 2009.

The plant is of 125.7 MW installed capacity and includes a Solar and a Combined Cycle Island. The Solar Island consists of parallel rows of Solar Collector Arrays (SCAs) and typical glass mirrors of 20 MW_e installed capacity. The solar collectors are 160 forming 40 loops covering 130,800 m^2. Regarding the Combined Cycle part, this consists of a gas turbine of 74 MW_e and a Heat Recovery Steam Generator (HRSG) which uses the exhaust gases from the gas turbine to produce superheated steam for the steam turbine (60 MW_e), Fig. 8. A cooling system will also be constructed in which the steam turbine exhaust will be condensed in the condenser and pumped to the dearator and then to the HRSG. Without sun, the capacity of the power plant will be reduced to 103.8 MWe.

The contracts of both the Combined Cycle and the Solar islands were signed on the 30th of September and 21st of October 2007, respectively. The expected budget is about 340 million $ of which 49.8 million $ come from a grant from GEF. The Ministry of International Cooperation covers the incremental cost, while an additional 170 million $ low-interest loan has been awarded from Japan [14].

2.4. Palestine

Palestine has a great potential for solar energy and more limited potential for other types of RES and has made significant progress in exploiting solar energy for thermal processes. The installed capacity of traditional SWH exceeds 1.5 million m^2, which accounts for the 48% of the installed capacity in the Arabic world. More than 70% of households use solar family systems, the most common of them being the thermosyphonic open circuit type in which the heated water is used directly by the consumer. There are significant applications for solar water heating in hospital buildings and hotels, even though the installed systems can only cover 40% and 25% of their hot water demand, respectively.

The potential of PV systems market seems to be high and several applications are feasible in Palestine, such as rural electrification, street lighting, telecommunication/transmission stations, and small-scale water pumping in remote areas.

2.4.1. Main stakeholders and review of policies

The Palestine Energy Authority (PEA) is the most significant stakeholder in Palestine's energy sector. Not only do they lay the legal, institutional, economic, financial and technical basis for efficient system development extending services to currently non-served communities, but also they reform the institutional framework. This includes overall sector coordination, policy formation, system development, generation, transmission, distribution, tariffs and regulation. PEA's personnel also supervise the technical details regarding the construction, operation, and maintenance of electrical projects and networks. Last but not least, PEA is being involved in research for all energy resources.

The Palestinian Energy & Environment Research Centre (PEC) is the national R&D institution responsible for programming and coordination of energy efficiency and renewable energy issues. PEC has been allocated as the focal point for all actions related to renewable energy and energy efficiency in Palestine. They conduct studies and researches related to energy and its influence on the local environment in Palestine and provide the National Authorities, decision-makers and interested parties with any information needed in the fields of energy and the environment.

Moreover, PEC presents significant activity in developing and implementing national programs for energy conservation, rational use of energy, and for utilization of renewable energy. They also develop energy seminars, awareness and training programs for upgrading human capacities and technical skills, and for the promotion of clean and efficient technologies. PEC co-operates with national institutions for the development of testing and research laboratories that support the standardization and regulation related to energy and represents Palestine in several international conferences and workshops.

Finally, the Energy Research Centre (ERC), which is connected to the An-Najah National University, is a research centre concerned with research, development, system design, feasibility studies and training in all conventional and renewable energy fields, energy

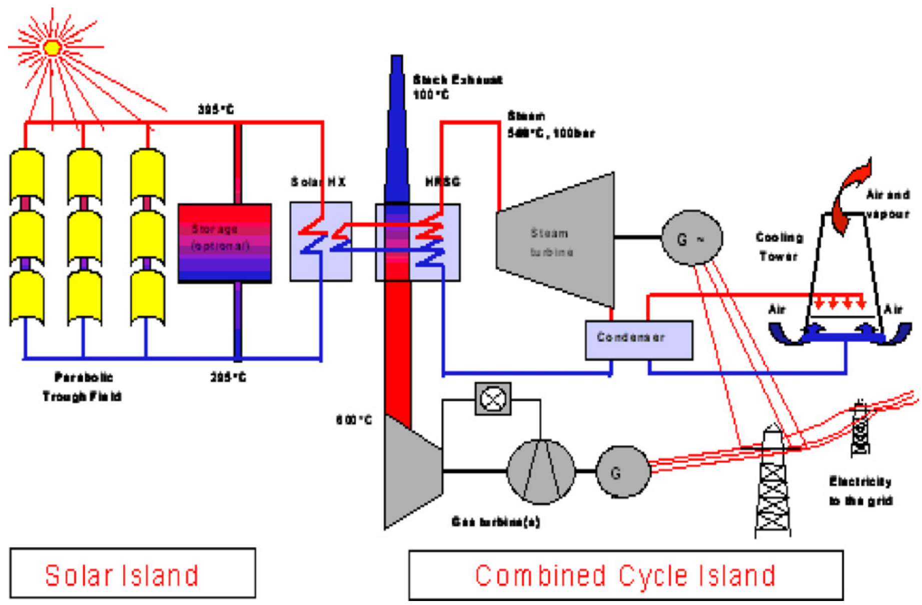


Fig. 8. The configuration of the Kurayamat power plant.

management and energy conservation. In early 2000, the scope of the centre was expanded to encompass the impacts of energy on global environment, health and social development. Other stakeholders responsible for electricity in Palestine are the various regional distribution companies in the major cities. All the above mentioned stakeholders are being focused on the same aim, to increase the rate of RE contribution in the energy balance of Palestine so as to reach 20% of the total final energy consumption.

Table 4
Various PV installations in Palestine.

Application	Number of systems	Installed capacity
Rural clinics	12	7.37 kW
Rural schools	21	13.44 kW
Bedouin tents	24	5 kW (typical size for each family 200–400 Wp)
Rural households	22	6.6 kW
Isolated village	1 central system	5.5 kW
Bedouin community	1 hybrid PV-wind system	4 kW
Rest applications		About 6 kWp

2.4.2. Best practices

Palestine is one of the countries that possesses a high solar potential (5.46 kWh/m^2 day), which makes Palestine being feasible for all types of solar energy applications, such as photovoltaic electrification and solar thermal energy. In 1995 PEC had started with pilot projects for PV applications through its clinic electrification program.

2.4.2.1. Rural electrification. There are some applications of Rural Electrification in Palestine. The most important one is the electrification of village Atouf, funded by the EU and An Najah University. The installed capacity is 24 kW$_p$, electrifying 25 houses, a school and clinics [32].

More than 90 SHS were installed through two main projects: the Eldorado German Program for promotion of PV technologies for public use in developing countries, and the Baden Wuerttemberg German PV revolving fund project for private uses. Another important tool is the GEF/UNDP projects (implemented under the supervision of PEA) for electrification of a small boarder Bedouin community and lighting a bridge in Gaza. A summary of the rest of installations is provided in Table 4.

Another Project for street lighting and electrification of public sites at the Jub-Altheib community has been recently implemented by Arij institution [33]. This project was financed by The United Nations Office for Project Services (UNOPS) and the total installed capacity is in the order of 150 kW.

The future policy of PV electrification focuses on settling the communities threatened from land confiscation and people eviction due to occupation practices, especially after the construction of the separation wall. The project or program (not fully specified yet) targets the electrification of 50 communities (about 800 families), with estimated total capacity of 350 kW$_p$. It will be implemented in stages, given priority to the Bedouin families and non electrified and politically threatened communities.

Even if the installation of a PV desalination system would be reasonable in those areas, most of the inhabitants are Bedouins and the lack of essential education makes the installation, operation and maintenance of a PV desalination system not suitable for the time being. However, there is a potential to electrify about 1100 isolated families in the un-electrified 65 communities to cover their social, health and education needs (schools, mosques, clinics, water pumping, etc.), reaching total capacity of about 560 kW$_p$. Further potential is envisaged for telecommunication and transmission stations, street lighting, agricultural farms and isolated houses in the periphery of rural villages, with capacity of about 40 kW$_p$.

The total potential is estimated at about 600 kW$_p$, providing energy equivalent of 660 MWh per year and avoided emissions of 460 tons CO_2. This corresponds to a total investment of about 3.6 million €. These figures are given for the current price of 6$/W$_p$ and a family demand of 1000 Wh/day, enough to cover the essential loads for lighting, refrigeration and television. In case the technology cost is lowered to be competitive with diesel, more potential is expected to switch off diesel decentralized generation or to use hybrid PV-diesel systems.

Further plans for exploiting wind energy, biomass and geothermal applications in Palestine are described in [34]. Recently the construction of a 300 kW PV plant in Jericho was announced, with co-funding by the Japanese government and starting its installation in February 2011.

Table 5
Summary of main targets for countries analyzed.

Algeria	Egypt	Lebanon	Morocco	Palestine
Commitment for increasing the solar and/or co-generation percentage of Algeria's energy mix to 5% by 2015	Long term strategy to increase the RE contribution in the energy mix to 20% by 2020	There is no specific national strategy as regards RES/DG	National Programme for Development of RES and Energy Efficiency: 10% in the energy balance and 20% in the total generated electricity by 2012	There is a central policy for PV electrification of rural communities. Aim to increase the rate of RE contribution in the energy balance to reach 20% of total final energy consumption

2.4.3. Other uses of solar energy

Use of solar energy for water desalination is still the subject of research and investigation in Palestine. Due to water shortage, high salinity (especially in the Gaza Strip) and eventually high cost of drinking water, solar desalination seems feasible for obtaining fresh water.

High potential of solar cooling/air-conditioning is foreseen for the food industry and service sectors where studies and researches are under preparation for the assessment of the potential and determination of applicable systems.

There is intention and interest at the Palestinian Energy Authority to invest in solar for power production CSP and water desalination thermal in Jericho and Gaza There are more concrete plans for a CSP plant of 100 MW out for Jericho and a feasibility study for a plant of 10 MWp has been prepared by the World Bank [35].

2.5. Lebanon

Lebanon presents the highest electrification rate among the countries studied. Thus penetration of stand alone systems based on PVs is expected to be limited. The major progress in solar energy exploitation refers to Solar Water Heaters installation which reached 348 million m^2 in 2009 [36]. The main stakeholders and policies regarding RES and few best practices are provided in the following sub-sections.

2.5.1. Main stakeholders and review of policies

The power sector has not yet a regulatory authority and, although the current sector law (in principle) endows the Ministry of Energy and Water (MoEW) with some basic regulatory responsibilities, this law dates back to the early 1970s. The MoEW has the responsibility for energy policy formulation and implementation. Another legacy of the war period is the lack of required personnel capabilities in Government ministries and state-owned companies. The MoEW has a very large proportion of its authorized staffing complement unfilled, and it lacks a sufficient frame of trained civil servants needed to manage the energy sector reform. This in turn contributes to a lag in policy definition, drafting of legislation and administration of reforms.

In the R&D field, the "National Council of Scientific Research (CNRS) is in principle in charge of research and development of all sectors in Lebanon, among which energy issues, in coordination with local universities. In fact, the CNRS had suffered for a long period from financial resources, making its role less important than it should have been. The Industrial Research Institute (IRI) is the responsible body for industrial R&D, in coordination with the Lebanese Industrial Association, but its action is still marginal. LIBNOR, an official organization attached to the council of ministries, is responsible to issuing norms. Another R&D stakeholder is the Lebanese Association for Energy Saving & for Environment (ALMEE) [37]. Created in 1992 gathers scientific experts hosted by the Notre Dame University (NDU) and professionals in energy. ALMEE has been focusing on Energy Saving and Environmental issues aiming to a Sustainable and Harmonious Development in Lebanon and in the Mediterranean countries. ALMEE is significantly interested in the global environment issues and within this context, the ALMEE researchers have been participating in numerous of studies, projects and activities in cooperation with several relative international organizations.

Lebanon has the target to reach RES penetration 5% (without Hydro) and 10% with Hydro by 2020. A long-term target of the country is by 2030 to reach 10% (without Hydro) and 15% with Hydro of electricity to be derived from RES. The PV capacity is not expected to exceed 1 MW by 2015 while these targets will not be accomplished unless some root barriers such as financial incentives for market penetration of RES technologies or combating lack of awareness in Lebanon. Nevertheless, the best practices described below, are the first concrete steps towards RE exploitation in Lebanon.

2.5.2. Best practices

Most of the population has access to electricity and thus the needs for rural electrification are very limited. The installed PV capacity is thus less than 50 kW in Lebanon. The most important installation is the one at the Monastery of Saints Sarkis and Backos of 15 kWs, operational since 2008. This installation is part of the RAMseS [38] (Renewable Energy Agriculture Multi-purpose System for Farmers) project supported by the European Commission's Framework 6th Programme. RAMseS concerns the development of an integrated all-solar power system based on the dual use of batteries, which not only provide energy storage, but also power for an all purpose electric vehicle. The aim of the project is twofold: the reduction in fossil energy consumption in agriculture (since the increase in fossil fuels prices is especially harmful for the sector) and thus the provision of a more clean solution for various farming tasks. Since agriculture vehicles are not as demanding as other electric vehicles in terms of distance autonomy and the speed they can achieve, it is believed that a solar tractor can be an attractive solution combining energy storage for both stationary and transportation applications [39].

Additional to exploiting solar energy via PVs, there are some research projects with participation of local stakeholders like ALMEE, in promoting use of solar energy either for air condition, REACT project [40] or for general exploitation in the building sector [41].

3. Comparative summary

RES penetration in the grids of MENA countries is currently rather limited to some wind power projects in Morocco and Egypt, as well as hydropower plants in Algeria, Morocco and mainly Lebanon.

In all countries, to a greater or smaller extend, the lack of subsidies and the very cheap electricity or even gas prices have been

Table 6
Integrated solar power plants under construction in MENA countries.

Morocco	Algeria	Egypt
2000 MW of combined CSP and Natural Gas plants by 2019. The first one of 470 MW is already under construction	"Hassi R'mel ISCC", an Integrated Solar Combined Cycle plant of 150 MW is under construction	Kurayamat, 140 MW of combined solar power plant and natural gas is currently under construction

Table 7
Summary of installations for rural electrification based on solar energy.

Country	Achievements	Future
Morocco	By the end of 2008: 12 million people in the rural areas (about 2 million households) During the period 1995–2008 the electrification rate in rural areas has increased from 18% to 98% 10% of the electrified rural areas have been solely based on PV kits Use of Private sector as an intermediate for implementing SHS projects via the "Fee-For Service" approach Small Wind turbines and Micro Hydraulic Projects have been also utilized	ONE has expressed the willingness to prolong PERG via PVER (Plan de Valorisation de l' Electrification Rurale) Take into account Clean Development Mechanism (CDM) in the implementation of rural electrification program
Algeria	20 solar villages till 2001 with around 500 kWp. Scattered village in an area of 1 million sq km^2 16 solar villages in the period of 2006–2009 – 800 dwellings and 500 kWp	Not a concrete plan yet but with strong commitment to promote solar energy. Vast areas due to low population density non-electrified yet
Egypt	Favourable wind power conditions additionally to solar conditions 2 remote settlements in Matrouh Governorate with PV systems of about 43 kW installed capacity, about 100 homes. Remote applications for scientific rooms	Rural Electrification of 121 Rural Villages via PV or PV/Diesel Systems is under investigation and the expected required capacity is about 1.2 MWp
Palestine	48% of the solar water heaters installed capacity in the arab world Village Atouf electrification funded by EU-An Najah University (24 kWp–25 houses, school and clinics Around 90 Solar Home Systems, about 100 kW	The project or program targets electrification of 50 bedouin communities (about 800 families), a total capacity of 350 kWp
Lebanon	RaMSES project, solar tractor with 15 KWp installed capacity	Not so many applications foreseen due to high electrification rate and lack of framework for RES

the main barriers for increasing RES capacity. Relatively recently decrees on RES and energy efficiency have been voted in Algeria, Morocco and Egypt, while Lebanon has started considering implementing such a law as well. Palestine has not implemented such legislation yet. The financial incentives are currently under revision in most of the countries examined, while mainly Egypt and Morocco have started considering environmental constraints in implementing RES projects. The stakeholders, presented for each country in the previous sections, make significant efforts in setting and implementing targets for increasing RES significantly as described above and as is summarized in Table 5.One of the driving forces in increasing RES capacity in those countries is the implementation of Integrated Solar Thermal Plants with Natural Gas to form Combined Cycle units. The most concrete plans for each country are summarized in Table 6. These countries have also made significant progress in rural electrification via solar energy and have updated their targets on this issue, as presented in Table 7.

4. Conclusions

MENA countries enjoy high solar radiation potential, among the highest of the world. Even though this has not been exploited as much as one would expect, local stakeholders have reviewed their targets in order to meet the local demand utilizing more and more this abundant resource. In this paper, the best practices till now in selected MENA countries have been reviewed and their targets on increasing RES share in their energy mix have been presented. Some of the applications are rather promising, while the updated targets of those countries in most cases are similar with the EU targets for 2020.

The CSP technologies become more and more mature, especially if combined in hybrid stations with Combined Cycle units. The latter are the type of power plants under construction in 3 countries of North Africa, namely Morocco, Algeria and Egypt. Algeria is the first country with legislative framework for private investments in this technology. The description of the characteristics of these plants show that the benefits of CSP technology can be significant in terms of fuel saving, RES penetration levels and local development. Within the next 10 years around 2500 MW of such plants will have been constructed, taking into account the mature plans already announced by these countries. If one takes into account the willingness of other countries in the region to construct such pilot plans [42], the installed capacity is expected to get even higher.

Therefore, CSP technologies hybrid with conventional plants in the beginning and with increasing solar field share later on can constitute a promising solution for electrifying these countries. Increase of capacity will also create economies of scale, which will reduce the cost and improve the economical feasibility of such projects, even at countries with lower solar potential such as the Southern European ones. If the interconnections with Europe are reinforced, the developed plants may constitute a significant solution in providing RES electricity at competitive prices to Europe. A highly optimistic project which is based on the above referred approach is DESERTEC. The DESERTEC Concept describes the perspective of a sustainable supply of electricity for Europe (EU), the Middle East (ME) and North Africa (NA) up to the year 2050 based on a close cooperation between these countries as well as on the interconnection of electricity grids by high-voltage direct-current transmission.

Last, but not least, MENA countries have been making efforts on increasing their rural electrification rates. Due to the long distances and the harsh conditions, the expansion of the high voltage networks for serving few dispersed customers may constitute a tedious and costly task. Experience from the MENA countries, as described above, has shown that the use of distributed generation based on solar energy, mainly PVs, can help significantly in improving, at competitive cost, the electrification rate with concrete social benefits to the local population. The approach described in MENA countries can be used as a paradigm for other countries facing similar difficulties, based on local adaptations.

Acknowledgements

The authors would like to thank the EC for funding the INCO FP6-2004-INCO-MPC-3-031569 research project DISTRES ("Promotion

and consolidation of all RTD activities for renewable distributed generation technologies in the Mediterranean region") and the partners of the project for their fruitful co-operation.

References

[1] The Desertec Initiative, available on-line at: www.desertec.org, last accessed on 13th of September 2010.
[2] DISTRES Promotion and Consolidation of all Research, Technological Development and Demonstration Activities for Renewable Distributed Generation Technologies in the Mediterranean Region INCO-031569, available on-line at: www.distres.eu, last accessed on 14th of September 2010.
[3] Ministry of Energy and Mines, available on-line at: http://www.mem.gov.ma, last accessed on 13th of September 2010.
[4] CDER (Centre de Dèveloppement des Energies Renouvelables, Morocco), available on-line at: www.cder.org.ma, last accessed on 13th of September 2010.
[5] Tenesol (formerly Total Energie), available on-line at: www.total-energie.com, last accessed on 13th of September 2010.
[6] Programme d'Electrification Rurale PERG, Office National d'Electricité (ONE), available on-line at: www.one.org.ma, last accessed on 13th of September 2010.
[7] Office National de l'Eau Potable (National Office of Potable Water), available on line at: www.onep.ma, last accessed on 13th of September 2010.
[8] An innovative successful example of a private–public partnership in decentralized rural electrification in Morocco. In: 3rd Future Environmental Trends Conference. 2006.
[9] Sifeddine Labed. PV Large Scale Rural Electrification Programs and the Development of Desert Regions, Sustainable Energy Production and Consumption, NATO Science for Peace and Security Series C: Environmental Security. Springer-Verlag; 2008. p. 281–92.
[10] Electrifying Rural Moroccan Households, Case Study, World Business Council for Sustainable Development; 2005, available on line at: www.wbscd.org, last accessed on 13th of September 2010.
[11] Summary of the survey on socio-economic impacts of rural electrification in Morocco, Office National d'Electricité, available on line at: www.one.org.ma, last accessed on 13th of September 2010.
[12] PVER (Plan de Valorisation de l' Electrification Rurale), available on line at: www.one.org.ma/FR/pdf/rural06.pdf, last accessed on 13th of September 2010.
[13] Integrated Solar Energy Generation Project, Kingdom of Morocco, available on-line at: www.one.org.ma, last accessed on 13th of September 2010.
[14] Centrale Thermo-Solaire a Cycle Combine Integre d'ain Beni Mathar, available on-line at: www.one.org.ma, last accessed on 13th of September 2010.
[15] Global Environment Facility, available on-line at: http://www.gefweb.org/, last accessed on 13th of September 2010.
[16] Ministère de l'Energie et des Mines, available on-line at: http://www.mem-algeria.org/english/index.php, last accessed on 13th of September 2010.
[17] Commission de Régulation de l'Electricité et du Gaz, available on-line at: http://www.creg.gov.dz/fr/accueil.htm, last accessed on 13th of September 2010.
[18] Agency for the Promotion & the Rationalisation of Energy Use APRUE (Algeria), available on-line at: www.aprue.org.dz, last accessed on 13th of September 2010.
[19] CDER (Centre de Développement des Energies Renouvelables – Algeria), available on-line at: www.cder.dz, last accessed on 13th of September 2010.
[20] SONELGAZ (Societe Algerienne de l Electricite et du Gaz), available on-line at: http://www.sonelgaz.dz/, last accessed 13th of September 2010.
[21] Sonatrach, available on-line at: http://www.sonatrach-dz.com/, last accessed on 13th of September 2010.
[22] NEAL (New Energy of Algeria), available on-line at: http://www.neal-dz.net/, last accessed on 13th of September 2010.
[23] Himri Y, Malik AS, Boudghene Stambouli A, Himri S, Draoui B. Review and use of the Algerian renewable energy for sustainable development. Renew Sust Energy Rev 2009;13(6–7):1584–91. August–September.
[24] Maafi A. A survey on photovoltaic activities in Algeria. J Renew Energy 2000;20(1):9–17. May.
[25] Bouzidi B, Haddadi M, Belmokhtar O. Assessment of a photovoltaic pumping system in the areas of the Algerian Sahara. Renew Sust Energy Rev 2009;13(4):879–86. May.
[26] Solar Power And Chemical Energy Systems, available on-line at: www.Solarpaces.org, last accessed on 13th of September 2010.
[27] Ministry of Electricity and Energy of Egypt, available on-line at: http://www.moee.gov.eg/, last accessed on 13th of September 2010.
[28] New & Renewable Energy Authority (NREA), available on-line at: www.nrea.gov.eg, last accessed on 13th of September 2010.
[29] Mohsen AA. Solar Opportunities for Egypt, El Nasr Pilot Steam Plant, available on-line at: www.eeaa.gov.eg/english/main/./Lotus%20for%20Env2003.ppt, last accessed on 13th of September 2010.
[30] Michael Geyer, IEA SolarPACES, Egypt START Mission Report, February 1996, Almeria,Spain, also available on-line at: http://www.solarpaces.org/News/Projects/Egypt.htm, last accessed on 13th of September 2010.
[31] Georg Brakmann S, Mohammad FA, Dolejsi M, Wiemann M. Construction of the ISCC Kuraymat, SolarPACES, 15–18 September 2009, Berlin, Germany, also available at www.fichtnersolar.com/./fichtnersolar_SolarPACES2009_Kuraymat_Brakmann.pdf, last accessed on 13th of September 2010.
[32] Mahmoud MM, Ibrik IH. Techno-economic feasibility of energy supply of remote villages in Palestine by PV-systems, diesel generators and electric grid. Renew Sust Energy Rev 2006;10(April (2)):128–38.
[33] Palestinian research and development institution, available on line at: www.arij.org, last accessed on 13th of September 2010.
[34] Yaseen BTQ. Renewable Energy Applications in Palestine. In: Proceedings of the DISTRES Conference, December 2009. 2009. Paper No. 103.
[35] The Palestinian Energy and Environment Research Center, available on-line at: http://www.perc.ps/, last accessed on 13th of September 2010.
[36] Matar T, Mourtada A, Zoghbi N, Jaber H, Chehab S, Solar thermal market in Lebanon, available on-line at: www.perpignan.cci.fr/files/marche-solaire-thermique-liban-juin-2010.pdf, last accessed on 13th of September 2010.
[37] Lebanese Association for Energy Saving & for the Environment, available on-line at http://www.almee.org/, last accessed on 13th of September 2010.
[38] RAMSES (Renewable Energy Agricultural Multi-purpose System for Farmers), http://www.ec-ramses.org, last accessed on 13th of September 2010.
[39] Mousazadeh H, Keyhani A, Mobli H, Bardi U, Lombardi G, Asmar T. Technical and economical assessment of a multipurpose electric vehicle for farmers. J Cleaner Prod 2009;17(November (17)):1556–62.
[40] REACT, Self-Sufficient Renewable Energy Air-Conditioning Systems for Mediterranean Countries, available on line at: www.crear.unifi.it/react/, last accessed on 13th of September 2010.
[41] RESSOL-MEDBUILD (RESearch Elevation on Integration of SOLar Technologies into MEDiterranean BUILDings), available on-line at: http://cordis.europa.eu/, last accessed on 13th of September 2010.
[42] Proceedings of the Joint Workshop of the World Bank Group and the African Development Bank MENA Regional Concentrated Solar Power Scale-up Program, Rabat Workshop. 2009, available on-line www.esmap.org/.